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PATENT SPECIFICATION

(11) 1 422 156

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(19)

(54) VACUUM-INSULATED PIPELINE ASSEMBLY

(71) We, BOC INTERNATIONAL LIMITED formerly known as The British Oxygen Company Limited, an English company of Hammersmith House, London W6 9DX, England, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a vacuum-insulated pipeline assembly which is suitable for the transfer of cryogenic liquid or gas.

In such assemblies it is known to support an inner cryogenic-fluid-conducting pipe by means of supports connected to an outer jacket enclosing the vacuum. Such supports provide a ready path for conduction of heat from the environment to the cryogenic liquid or gas. In a system in which liquid helium is supplied from a liquefier to refrigerate a load such losses of refrigeration caused by the inleak of heat must be compensated for by expending extra energy in the liquefier. In producing liquid helium the energy required to give a unit quantity of liquid is very great. It is thus of great importance to increase the insulative efficiency of a vacuum-insulated pipeline used for transporting helium at cryogenic temperatures.

According to the present invention there is provided a vacuum-insulated pipeline assembly, including an inner pipe which is surrounded by layers of superinsulation (as hereinafter defined) and which is located within a tubular jacket enclosing the vacuum, wherein the pipe is spaced apart from the jacket by several spacing members, each spacing member comprising a ring positioned within the tubular jacket and having attached thereto two or more inwardly extending members supporting the pipe either directly or indirectly, and wherein the rings, or outward projections therefrom are in frictional engagement with the inner surface of the tubular jacket without there being intervening layers of superinsulation between the rings and the tubular jacket.

In the context of this specification the term "layers of superinsulation" indicates layers of spaced-apart reflective metal. For example, the superinsulant may comprise alternate layers of aluminium foil and nylon net, the foil providing insulation against radiative heat, and the net reducing conduction between adjacent layers of aluminium foil.

The rings are preferably of a heat-insulative material.

The layers of superinsulation may be wound directly around the pipe. Alternatively or additionally the layers of superinsulation may be disposed around a tubular mandrel within which the pipe is located. If desired there can be more than one pipe. If there is more than one pipe it is preferred that the layers of superinsulation be located around a mandrel and the pipes held in the generally annular space formed between the mandrel and an inner sleeve. In general, winding multiple layers of superinsulation round a pipe is a difficult task requiring considerable manipulative skill. The use of a mandrel provides the advantage that it may be rotated to facilitate the winding of the layers of superinsulation.

The pipe may be held within the mandrel by means of several axially spaced-apart resilient spacing rings engaged between the pipe and the mandrel. Preferably if more than one pipe is required supported within the mandrel are several sleeves spaced axially apart from one another, the pipes being engaged between the mandrel and the sleeves and there being several resilient spacing rings which are spaced axially apart from one another and which are engaged between the pipe and the inner surface of the mandrel.

In one form of assembly the support members extend radially inwards from each ring and comprise two or more rigid probes which exert pressure upon the layers of superinsulation.

The pressure exerted by the probes upon the layers of superinsulation is effective to support the pipe or mandrel.

Preferably each probe is of material

having a low thermal conductivity. A suitable form of probe is provided by a member which is in screw-threaded engagement with the ring. If a mandrel is employed it preferably has a cup attached to its outer surface to receive the regions of the layers of the superinsulation which are compressed by the action of the probes.

It is preferred that each ring has attached thereto three probes equally spaced around its periphery. If just two probes are employed it is unlikely that the pipe will be sufficiently supported. On the other hand more than three probes may cause undue compression of the superinsulant.

In view of the compression of the superinsulation caused by the probes it is desirable to use layers of superinsulant having insulative properties that are not greatly impaired by compression. One such superinsulant includes layers of aluminium each coated on one face with a polymer film which preferably has a slightly rough surface. In one form of this superinsulant an aluminium film is deposited on either face of a polyester sheet and the polymer film deposited on one of the aluminium films. The roughened surface of the polymer film ensures that there is only point contact between adjacent sheets when the superinsulant is compressed, and thereby the amount of heat that is conducted across the superinsulant is minimised.

In the conventional type of assembly, layers of superinsulation are disposed between supports extending directly between the pipe and the jacket. In order for the pipe to be properly supported the space between adjacent supports is limited. With such a conventional type of assembly there are thus significant refrigeration losses by radiation of heat through the gaps between the lengths of superinsulation in the region of the supports.

Since in the form of assembly according to the invention that includes probes there is no need for there to be a break in the superinsulation between supports radiation losses may appreciably be less than in the aforesaid conventional arrangement.

In another form of assembly according to this invention, the inwardly extending members supporting the pipe comprise three or more flexible members to which the pipe is connected. In a preferred arrangement three flexible support members are equally spaced about both the inner surface of the ring from which they extend and the pipe to which they are connected. If a mandrel is employed the flexible support members may extend through apertures therein. This arrangement permits the pipe to remain centrally located within the jacket even when forces caused by thermal expansion or contraction are tending to displace it. Thus there is no need for spacing rings between the pipe and the mandrel. This enables the mandrel to be located close to the pipe to minimise the space therebetween. Such an arrangement provides more efficient heat-insulation than that employing spacing rings.

Preferably the flexible support members are of low conductive or heat-insulative material, for example nylon, and will withstand considerable strains.

In the forms of assembly including the flexible support members there is no problem concerning compression of the superinsulant layers. On the other hand it is necessary to allow for axial gaps between layers of superinsulation.

These gaps may, however, be small in comparison with conventional arrangements owing to the fact that the flexible support members need be of slender cross-section only. Thus, achievement of negligible radiation window losses is made possible.

The forms of assembly according to this invention offer the advantage that there is no direct heat-conductive connection between the jacket and the pipe or pipes by means of a support for the pipe or pipes.

The invention is now described by way of example with reference to the accompanying drawings, of which:—

Figure 1 is a schematic diagram, partly in transverse section, of one form of a vacuum-insulated pipeline assembly according to this invention;

Figure 2 is a schematic diagram, partly in transverse section, of a second form of vacuum-insulated pipeline assembly according to this invention; and

Figure 3 is a schematic diagram, partly in transverse section, of a third form of vacuum-insulated pipeline assembly according to this invention.

In the form of pipeline assembly shown in Figure 1, a pipeline 2 is located within a jacket 4. The pipeline 2 is insulated by means of a vacuum in the space between itself and the jacket 4 and by means of layers 6 of superinsulation which are located around a mandrel 8. The mandrel 8 is coaxial with the pipeline 2 and is supported by means of three nylon screws 10 which grip the layers 6 of superinsulation. Cups 12 are welded to the outer surface of the mandrel 8 to receive the areas of the superinsulative layers upon which the screws 10 act. The screws 10 extend from and are equally spaced about a ring 14. The heads of the screws 10 are held in position by frictional engagement with the inner surface of the jacket 4. The pipeline 2 is supported by means of a resilient ring 16 held between the mandrel 8 and the pipeline 2. It can be seen that there is no direct heat conductive path

between the pipeline 2 and the jacket 4.

In a typical assembly support rings 14 are located at intervals of 5ft. The resilient ring 16 between the pipeline 2 and the mandrel 8 are similarly located at intervals of 5ft. The superinsulation includes about 60 layers of polyester located around the mandrel 8 each having an aluminium film deposited on either side and a polymer film. A slightly roughened surface facing one side of aluminium film is preferred.

On receiving a cryogenic liquid the pipeline 2 tends to contract. If it is formed with one or more bends in it the contraction will tend to displace the pipeline 2 from its coaxial location within the jacket 2 but this movement is constrained by the action of the screws 10.

In the form of pipeline assembly shown in Figure 2 the pipe 2 is suspended by means of three pairs of nylon threads 18 connected to and equally spaced around the support ring 14, and leading through apertures in the mandrel 8 to suspension points on the outer surface of the pipe 2. With this arrangement there is no disadvantageous compression of the superinsulant and thus compared with the Figure 1 arrangement, screws and cups are not required. Similarly as the pipe 2 is directly held in position by means of the nylon threads 18 support rings are not required. The mandrel 8 can therefore be made of a narrower diameter to minimise the space between it and the pipe 2. This improves the insulative efficiency of the assembly. In addition, the rings 14 are in frictional engagement with the tubular jacket 4.

In the form of assembly shown in Figure 3, six pipes 20, 22, 24, 26, 28 and 30 are located within the annular space formed between an outer mandrel 8 and an inner sleeve 32. In order to ensure that the pipes are not displaced radially by thermal contraction or expansion a resilient ring 16 is held in engagement with the inner surface of the mandrel 8 by means of the pipes 20 to 30.

In a typical assembly the sleeves may be a foot in length and may be located at intervals of 10 ft. They may be supported by connecting members (not shown) leading therefrom to the mandrel.

WHAT WE CLAIM IS:—

1. A vacuum-insulated pipeline assembly, including an inner pipe which is surrounded by layers of superinsulation (as hereinbefore defined) and which is located within a tubular jacket enclosing the vacuum, wherein the pipe is spaced apart from the jacket by several spacing members, each spacing member comprising a ring positioned within the tubular jacket and having attached thereto two or more inwardly extending members supporting the pipe either directly or indirectly and wherein the rings, or outward projections therefrom are in frictional engagement with the inner surface of the tubular jacket without there being intervening layers of superinsulation between the rings and the tubular jacket.

2. A vacuum-insulated pipeline assembly as claimed in claim 1, in which each ring is of heat-insulative material.

3. A vacuum-insulated pipeline assembly as claimed in claim 1 or claim 2, in which at least some of the layers of superinsulation are wound directly around the pipe.

4. A vacuum-insulated pipeline assembly as claimed in any one of the preceding claims in which the support members extend radially inwards from each ring and comprise two or more rigid probes which exert pressure upon the layers of superinsulation about the pipe.

5. A vacuum-insulated pipeline assembly as claimed in claim 4, in which there are three probes spaced equally about the ring.

6. A vacuum insulated pipeline assembly as claimed in claim 4 or claim 5, in which the probes are formed of material having a low thermal conductivity.

7. A vacuum-insulated pipeline assembly as claimed in claim 4 or claim 5, in which the probes are in screw-threaded engagement with the support ring from which they extend inwardly.

8. A vacuum-insulated pipeline assembly as claimed in any one of claims 1 to 3 in which the support members extending inwards from each ring comprise three or more elongate flexible members to which the pipe is connected.

9. A vacuum-insulated pipeline assembly as claimed in claim 8, in which the flexible members are equally spaced about both the inner surface of the ring from which they extend and the pipe to which they are connected.

10. An vacuum-insulated pipeline as claimed in claim 8 or claim 9, in which the flexible members are of material having a low thermal conductivity.

11. A vacuum-insulated pipeline as claimed in claim 10, in which the material is nylon.

12. A vacuum-insulated pipeline assembly as claimed in any one of the preceding claims in which the pipe has disposed thereabout a tubular mandrel around which at least some of the layers of superinsulation are situated.

13. A vacuum-insulated pipeline assembly as claimed in claim 12 when dependent from any one of claims 4 to 7, in which engaged between the pipe and the mandrel are several axially spaced-apart resilient spacing rings.

14. A vacuum-insulated pipeline assembly

as claimed in claim 12 when dependent from any one of claims 4 to 7, or as claimed in claim 13, in which the mandrel has cups attached to its outer surface to receive the regions of the layer of superinsulation that are compressed by the action of the probes.

15. A vacuum-insulated pipeline assembly as claimed in claim 12 when dependent from any one of claims 4 to 7, in which there is more than one pipe within the mandrel.

16. A vacuum-insulated pipeline assembly as claimed in claim 15, in which supported within the mandrel are several sleeves spaced axially apart from one another, and in which the pipes are engaged between the mandrel and the sleeves, there being several resilient spacing rings which are spaced axially apart from one another and which are engaged between the pipes and the inner surface of the mandrel.

17. A vacuum-insulated pipeline assembly substantially as described herein with reference to , and as shown in any one of the accompanying drawings.

For the Applicants,
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1422156 COMPLETE SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

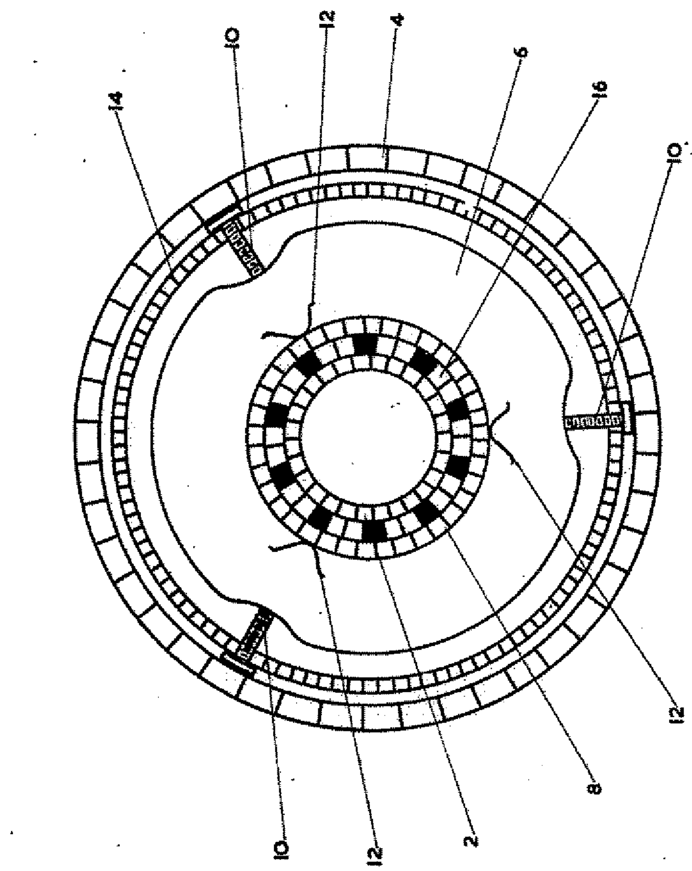

FIG.1

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

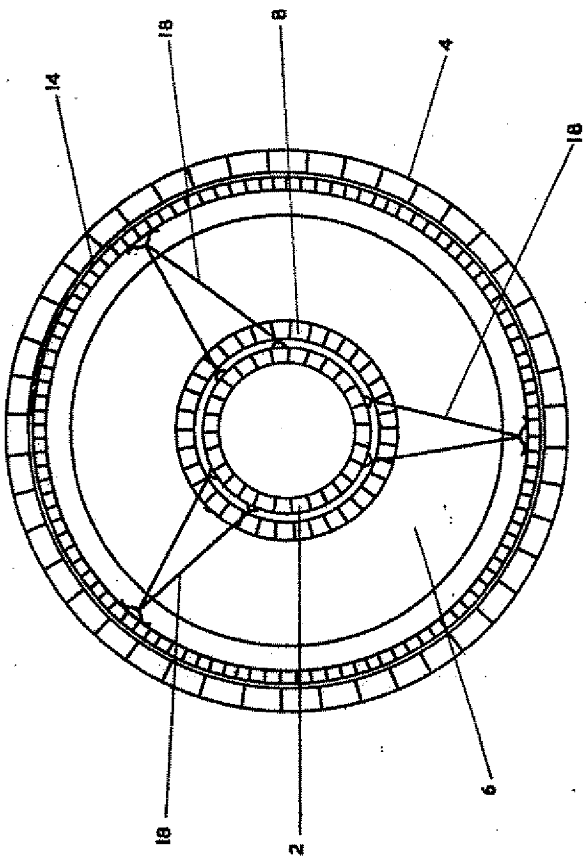

FIG. 2

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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

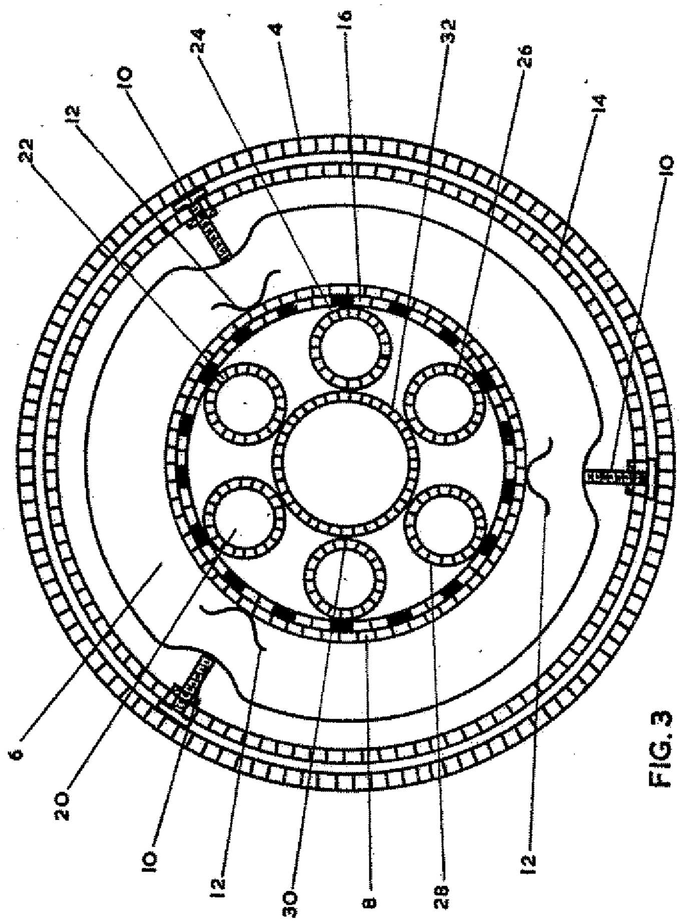

FIG. 3